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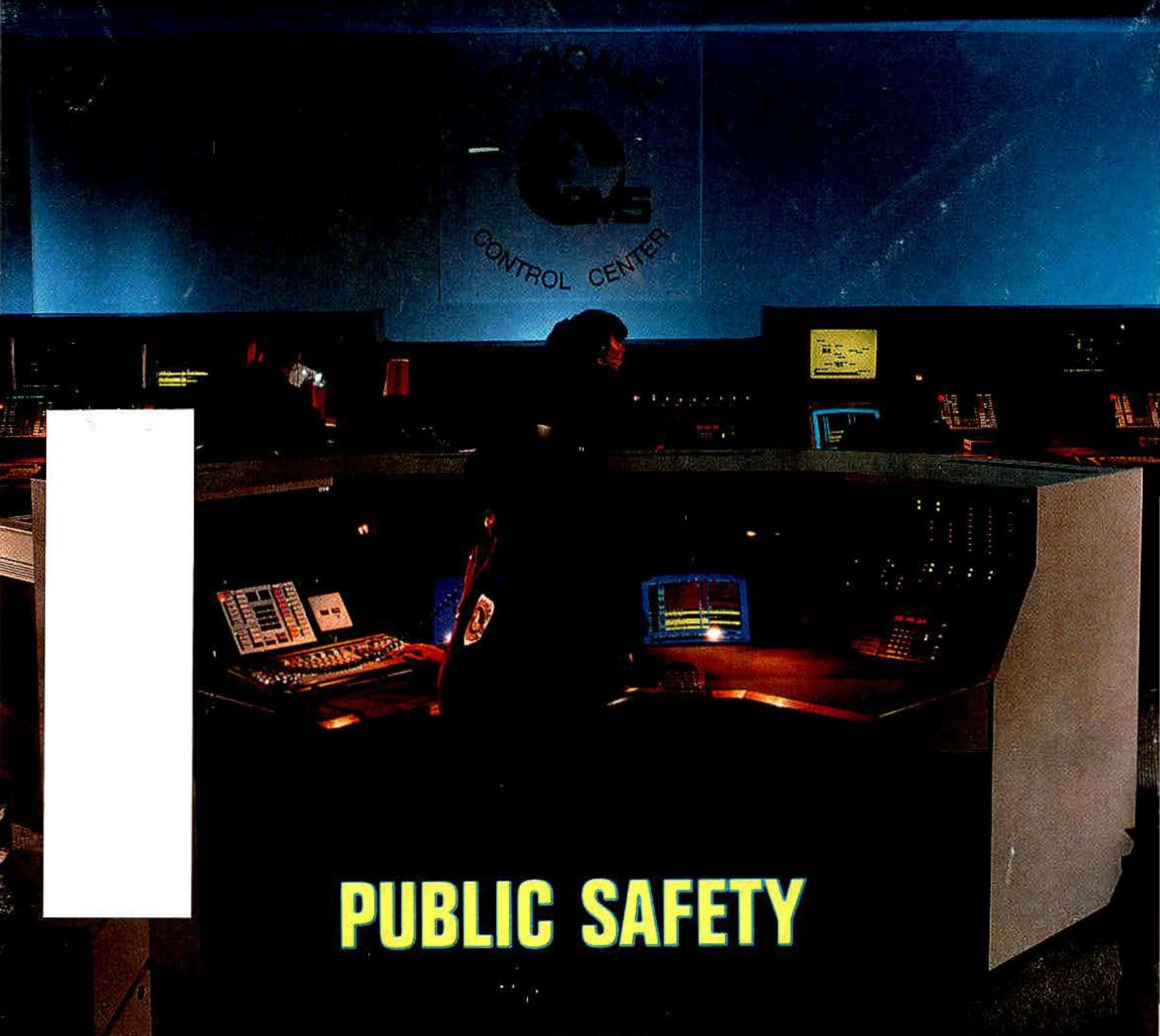

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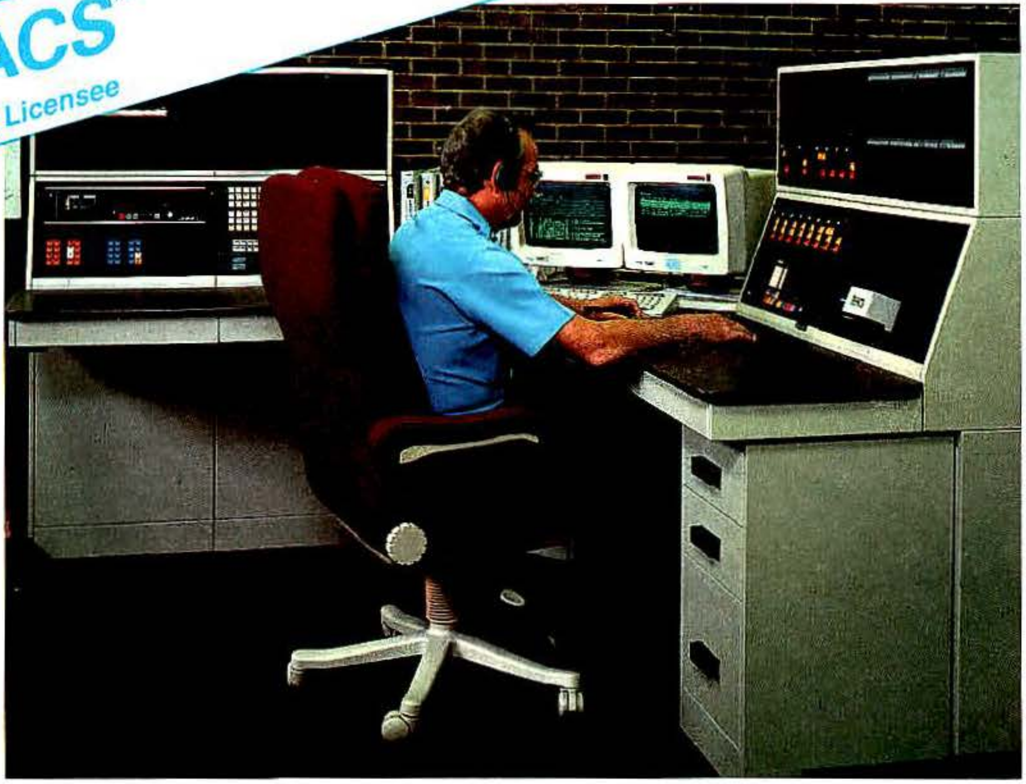

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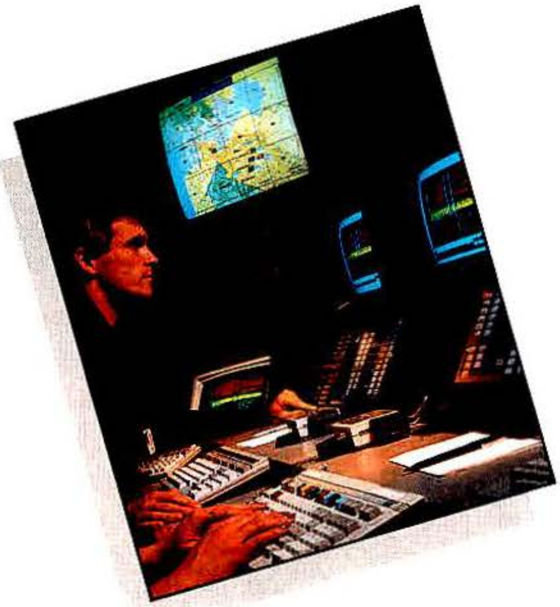

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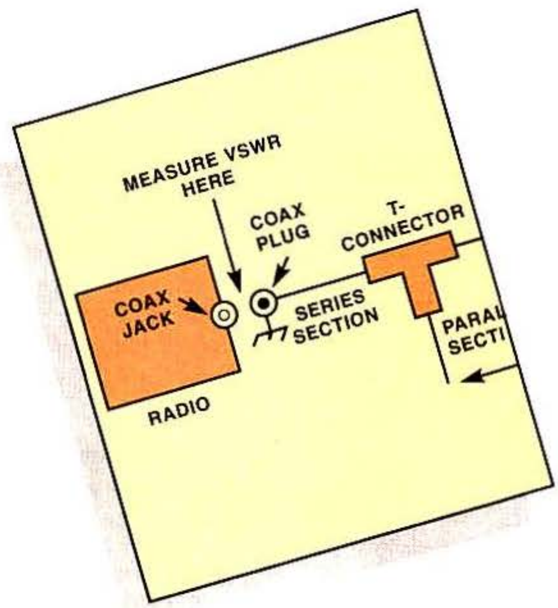

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On the cover: During peak traffic, as many as 13 people staff the Regional Medical Systems communications center in Fremont, CA. The center was designed with convenient equipment mounting, ergonomics, aesthetics and acoustics in mind. See Sam Kichas' article on page 6.

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Regional Medical serves four California counties

A multichannel radio system with automatic vehicle location, computer-aided dispatching and a dedicated data radio subsystem helps a large ambulance service company to provide medical service in Northern California.

By Sam N. Kichas

Advanced life support (ALS) and basic life support (BLS) services are dispatched to 4 million people in four Northern California counties through the Regional Medical Systems communications center in Fremont, CA.

Regional is the largest paramedic service provider in the western United States. Consolidation among several ambulance services into one company brought about the construction of the 1,000-square-foot communications center where highly trained operators track, dispatch and coordinate 150 ambulances.

Regional's full-time staff includes a director of communications, 34 dispatchers, four supervisors, four statistical analysts and an administrative assistant. No part-time dispatchers are employed.

During a typical day, Regional dispatches about 100 ambulances, with a targeted emergency response time of 10 minutes. The control center also dispatches CALSTAR, an aero-med transportation service, which operates three EMS helicopters.

Advanced communications systems

To accomplish its dispatching mission, Regional uses exclusive frequencies for open communications capabilities throughout the San Francisco

Kichas is director of corporate marketing, Skaggs Telecommunications Service, Murray, UT.

Information in this article was obtained through interviews with, and material supplied by, Denis Jackson, director of strategic deployment, American Medical Response West, Fremont, CA.

Bay area.

Custom equipment fits the service area's geographical characteristics for clear, static-free voice and data communication to support the rapid deployment of emergency medical service (EMS).

For fast and accurate information exchange, Regional designed and installed a dedicated data radio system in each vehicle. The data are fed into the automatic vehicle location (AVL) and computer-aided dispatch subsystems.

Regional's AVL data are carried on a VHF lowband channel capable of supporting data traffic for as many as 200 ambulances. Status changes and pre-coded messages can be sent directly from an ambulance to control center computers, minimizing voice traffic volume and providing a reliable database for monitoring system performance. Changes in status, times and transport destinations are reported virtually as they occur.

The CAD system is designed to handle the most demanding EMS operating conditions. This sophisticated system allows for flexible deployment of vehicles and employees; workload analysis; unit hour utilization ratios; geo-file and address matching capabilities; and status planning.

Additionally, Regional has installed satellite and lasermap systems to provide instant vehicle location, status and tracking data. Real-time images of all vehicle locations are projected on analog video maps displayed on high-resolution monitors. (See photo on page 8.)

Icons of various colors and shapes represent on-duty ambulances and allow controllers to monitor and identify the location and status of active units continuously. The satellite system is capable of polling and updating 50 ambulances in less than 14 seconds. Data are transmitted via modem from sensors positioned on each vehicle's roof.

Custom-built furniture

During peak traffic, as many as 13 people occupy the control room, so convenient equipment mounting, ergonomics, aesthetics and acoustics were important design considerations. (See cover photo.)

Regional commissioned custom-built furniture to house its communications systems. The control center floorplan provides for a long, "U" shaped configuration with a supervisor's console centrally located to permit easy observation of all stations. (See Figure on page 10.) Additionally, workstations for two call receivers are positioned behind the supervisor.

Each of the six sections that comprise the main operators' console incorporates a stepped countertop to accommodate computer keyboards, and the three single stations include recessed keyboard areas. All consoles house multiple display and electronic chassis and provide channeling for coax and power cables to the rear panel areas. Custom-designed bezels for oversized, high-resolution monitors are incorporated.

The furniture framework is welded tubular steel for maximum stability, and the exterior finish work is gray laminate with hardwood trim.

'Baptism by fire' in Oakland

The possibility of a disaster always is foremost in the minds of EMS pro-

Above: On Oct. 20, 1991, fire swept Oakland, CA, killing 25 people and injuring 150. Regional Medical System employees worked around the clock to provide emergency services.

Regional uses satellite and lasermap systems to provide instant vehicle location, status and tracking data. Real-time images of vehicle locations are projected on analog video maps displayed on high-resolution monitors.

viders and makes preparedness a critical issue.

At about 12:30 p.m. on Oct. 20, 1991, conditions were perfect for a disaster. Ambient temperatures higher than 90°, low humidity and transitional winds combined in Northern California's Alameda County to provide ideal circumstances for the previous day's brush fire to rekindle and spread. (See photo on pages 6 and 7.)

And spread it did, becoming a raging inferno that quickly covered more than 1,800 acres (2 square miles). By the time it was over, damage was estimated to exceed $1.5 billion; 25 people were confirmed dead; 150 were injured, and two were reported missing.

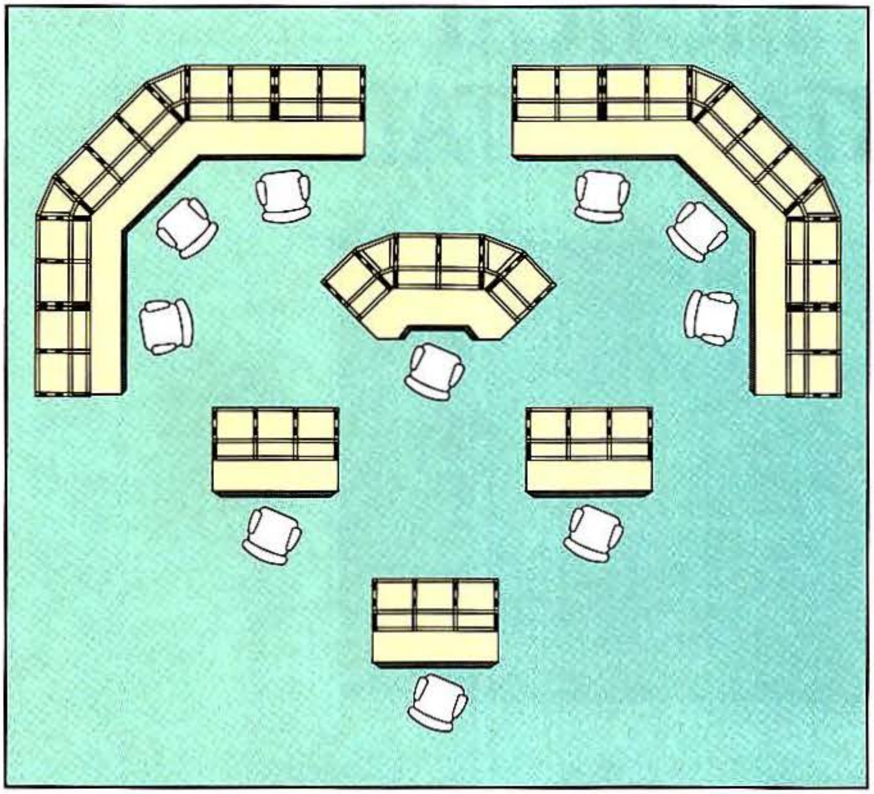
Regional's Alameda County Division deployed 27 units and 43 support and management employees during the 12-hour red alert. (Yellow alert occurred at 12:26 p.m. and moved to red alert at 1:38 p.m.)

Regional employees established and staffed two medical command centers that coordinated operations with the Fire Incident Command Post and provided for triage treatment and staging plus medical collection (morgue) areas. Paramedics, emergency medical technicians (EMTs) and other medical workers were dispatched and coordinated through these centers.

With temperatures reaching 2,000°F in some areas, street signs and traffic signals literally melted away. Ambulances that were sent directly into the fire area had to be escorted by people who were personally familiar with the various locales to maintain an accurate sense of direction.

Ten area hospitals were designated to receive victims, and at one point during the disaster, the four hospitals nearest to the fire tentatively were scheduled for evacuation.

As it happened, though, at the rate the fire was spreading, there would not have been ample time to evacuate one, let alone four, hospitals. Luckily, evacuation never became necessary,



This floorplan shows custom-designed console arrangements for the 1,000-square-foot control center.

and at approximately 1 a.m. on Oct. 21, the red alert was canceled.

Emergency 'territory'

Regional Medical has handled more than one disaster in the past few years.

For example, Regional had a key role in providing EMS during the Loma Prieta earthquake that struck San Francisco in 1989.

As part of an elaborate back-up system maintained at Regional's facilities, a 50,000kW generator stands ready to power the control center whenever utility power fails. Every protective measure possible has been considered in the facility design to ensure that Regional's ambulances and paramedics are ready to roll when the next emergency occurs.

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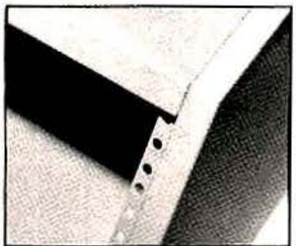

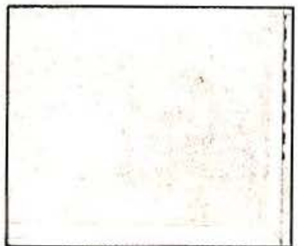

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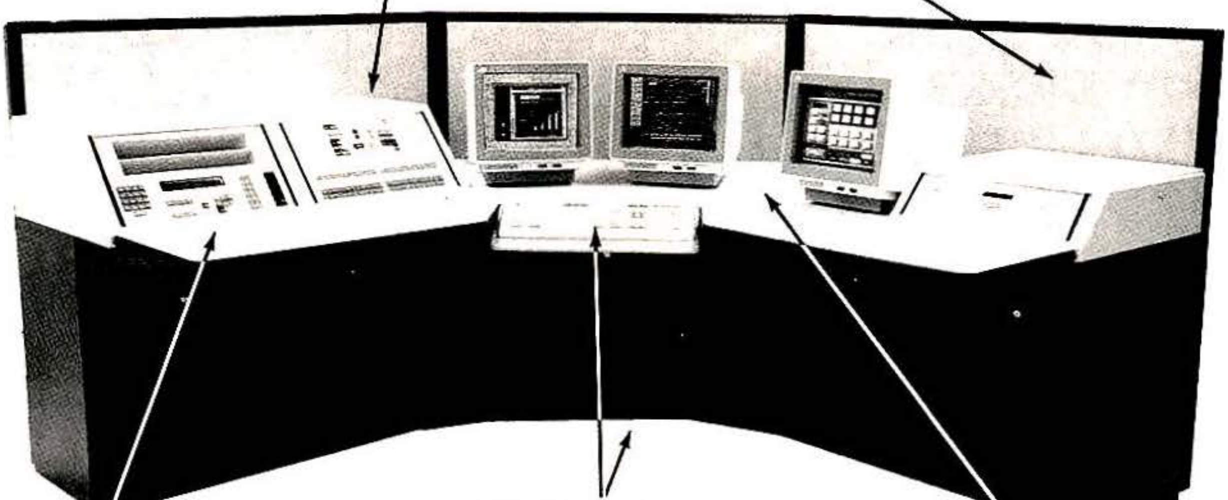

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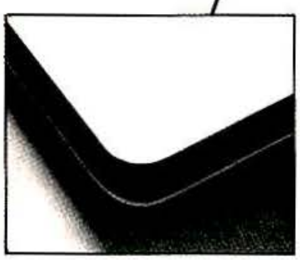

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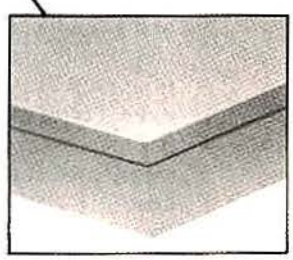

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Use coaxial filters to reduce interference

Public safety base stations in rural communities sometimes are subject to interference when co-located dispatching radios are used simultaneously. Simple filters can help as temporary remedies and to isolate causes.

By Donald E. Koehler

Inexpensive phasing harnesses described in the July 1992 issue* brought to mind another use for reactance in coaxial cables—coax stub filters.

Using stub filters can save money that otherwise might be spent on commercial filters when they are used temporarily while an interference problem is investigated. Let's review some uses for stub filters and general interference troubleshooting for the field technician.

Public safety agencies in rural communities often face equipment problems, budget limitations and staff shortages. Although many agencies operate successfully under austere conditions, reducing costs reflects positively on the service they provide. Many small communities operate two-way radio, paging and dispatching functions from a single facility or room. Police officers, firefighters, ambulance crews and even, in some cases, road maintenance workers are centrally controlled and dispatched from these facilities.

In most cases these services operate radios on different frequencies or band segments in the VHF and UHF spectrum. Simultaneous use of these radios can result in interference.

Before purchasing what may be an expensive commercial filter to remove an offending signal, try a few virtually cost-free remedies.

*"Combining and Phasing Land Mobile Base Antennas" by Brian Henderson, P.Eng.

Koehler is a technical writer; technical resource researcher; and computer, communications and database specialist for Hartec Management Consultants, Anchorage, AK.

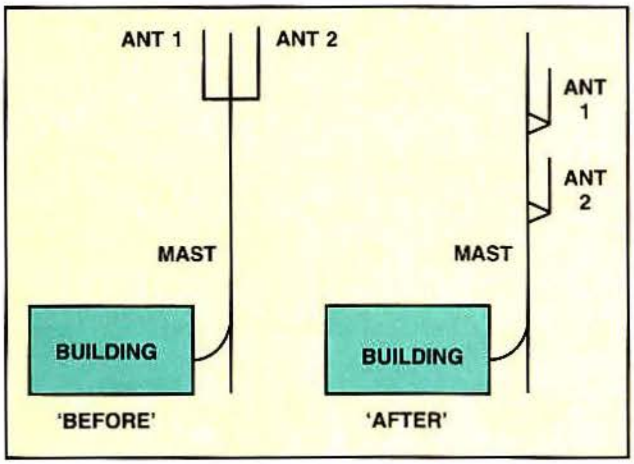


Figure 1. One possible interference solution is to stack the offending antennas vertically a few feet apart, one over the other and on a common mast or mount to provide as much as 20dB of attenuation.

'Free' remedies

First, check for bad coaxial cable and connectors.

On low-cost systems, the temptation to skimp on coax or fittings during installation may have been too great to resist. Stacking the offending antennas vertically a few feet apart, one over the other and on a common mast or mount, can provide as much as 20dB of attenuation. (See Figure 1 above.)

Ensuring that the ground system is a continuous, unspliced conductor run to a common tie point helps to eliminate possible common mode interference sources. This tie point must be connected to a low-resistance ground.

Double-check this ground point with a temporary ground rod and spectrum analyzer if you do not have a dedicated ground tester. You may see that the ground isn't *clean*. If so, the external ground and tie point can be replaced or serviced.

If the interference persists after trying these less expensive remedies, try the stub filter.

Filtering

Interference problems often are solved with a commercial tunable cavity or with crystal bandpass filters.

When the interference is limited, intermittent or when it appears on a single channel, a lower-cost option is available. The use of a coaxial cable stub filter may reduce the interference sufficiently. In addition, it may be used temporarily to reduce the problem until a commercial filter can be installed.

Once in a while, the stub filter is enough to fix the problem.

The coaxial stub filter is used as a receive notch filter. The filter attenuates the undesired signal, allowing the desired RF energy to reach the radio set.

Although assembling the stub filter is easy, tuning the filter to the correct frequency requires a spectrum analyzer and tracking generator or signal generator. A small amount of math allows you to cut the filter to an approxi-

mate length. Then, the test equipment helps you to trim the filter to the exact length of coaxial cable needed.

The formula for a quarter-wavelength of cable is as follows:

$$L = (246)(VF)/f$$

where

L = length in feet

f = frequency in MHz

VF = the cable's velocity factor.

Multiply L by 12 to convert the cable measurement to inches.

Table 1 on page 14 gives the velocity factors for common types of cable.

If a quarterwave coaxial stub is left open, it appears as a series resonant circuit. When measured with a tracking generator and spectrum analyzer at its resonant frequency, the stub exhibits a low reactance.

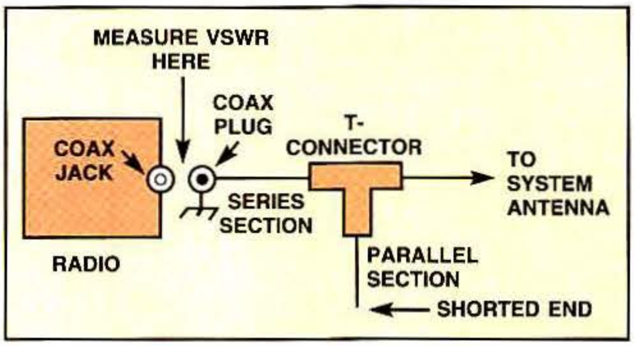


Figure 2. The shorted stub coax filter looks like a T with one upper arm broken off. The two coax 'sections' are cut to length using the formula in the text.

When one end of the same stub is short-circuited and the stub is remeasured in the same way, it appears as a parallel resonant circuit. The shorted stub then exhibits a high reactance at its resonant frequency.

Thus, the shorted stub can be used to eliminate interference.

Making the filter

To make a shorted stub coax filter, assemble a coax "section" with a connector at each end and another "section" with a connector at one end only. Using the formula to calculate the approximate length for the desired frequency, cut two "sections" of 50Ω coaxial cable.

Assemble connectors on both ends of one measured piece of cable. This "section" of cable with two connectors is used to attach the filter to the communications equipment.

On the other measured section, assemble only one connector. These two sections mate to a T adapter. First, attach the cable with two connectors to one end of the coax T fitting, leaving the other two sides open. Then, take the cable with only one connector and connect it to the bottom of the T fitting, 90° from the first.

The result should look like a T with one upper arm broken off. (See

Figure 2 on page 13.)

Tuning the filter

To tune the stub filter, use a spectrum analyzer, a tracking generator or signal generator, and a calibrated cable. The calibrated cable is the one you normally use with the spectrum analyzer; it is a cable known to be *flat*, that is, without significant attenuation, in the filter's operating frequency range.

Attach the filter cable to the spectrum analyzer. Attach the calibrated cable to the open end of the filter T fitting from the tracking or signal generator and look at the notch produced by this filter arrangement as displayed on the analyzer. With filters I have built using this method, the notches are both deep and easy to see.

To adjust the filter exactly to the interfering frequency, trim the bottom of the stub on the filter. Remember, the interfering signal is the one to notch out, so the filter should be made so it causes no problems on the transmit frequency. Check the antenna cable SWR at the radio, ahead of the filter, just to be sure.

Table 1—Common coaxial velocity factors.

CABLE	VELOCITY FACTOR	TYPE
RG-8X	75	Foam
RG-8	66	PE
RG-8	80	Foam
RG-58	66	PE
RG-58	79	Foam
RG-58A	66	PE
RG-213	66	PE
RG-214	66	PE

As you tune the filter, take a moment to look at the difference opening and shorting the trimmed end of the filter makes on the spectrum analyzer display. If you have the time to spare, remove the other cable (the one with the double connector that you assembled) and see the difference it makes.

These two pieces of cable make up both series and parallel resonant sections of the filter. Testing these cables makes a good training demonstration for students or new technicians who cannot quite grasp the concept of resonance.

Coaxial stub filters are not intended to replace commercial, tunable filters; nevertheless, most technicians carry enough surplus parts in the field to make this kind of a filter as a temporary remedy for an interference problem.

This type of filter has been used several times to put an airfield communication system back on line while the cause of interference was being determined.

The coaxial stub filter sometimes can be used to demonstrate to a customer that a communications problem is external to the system. Moreover, a stub filter can provide a temporary solution to the problem before a purchase order is signed.

Police radar hazards: Separating fact from fiction

Does electromagnetic radiation from police radar speedguns threaten the health of the radar operator or the general public? RF radiation from current traffic radar equipment falls well within the OSHA standard.

By Mel Weimeister

Radiation is scary. Just the mention of radiation raises thoughts of accidental spills and people who glow in the dark, or radioactive clouds drifting toward a metropolitan area from a nearby atomic reactor.

Yet, electromagnetic radiation exists in nature. All objects warmer than absolute zero emit electromagnetic radiation.

Various man-made devices emit electromagnetic radiation intentionally (radio transmitters, radars and x-ray machines, for example) or incidentally (computers, radio and TV receivers and electric lines).

For the purpose of discussing health effects, electromagnetic radiation usually is divided into two categories, *ionizing* and *non-ionizing*.

Atomic reactors and x-ray machines emit ionizing radiation, including alpha, beta and gamma rays or particles. Ionizing radiation can modify cell growth or body structures. People regularly exposed to ionizing radiation must be monitored for accumulated dosage.

Radio-frequency (RF) electromagnetic radiation is non-ionizing. Broadcast stations, microwave radios and ovens, portable two-way radios and radar speedguns emit RF radiation.

The fact that food can be cooked in a microwave oven is evidence that exposure to RF energy carries a level of risk. The question is: What level of exposure creates a hazard, and how does one avoid hazardous exposure?

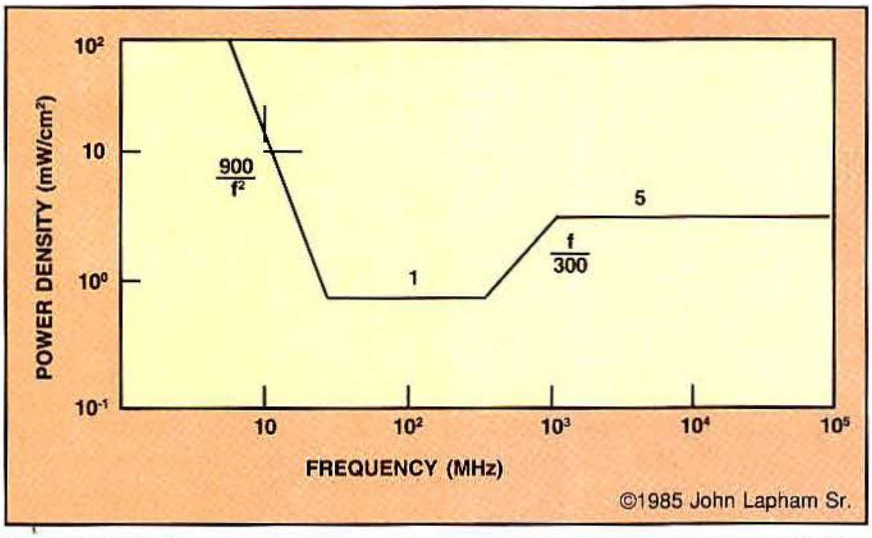


Figure 1. Radio frequency protection guide for whole-body exposure of human beings is based on an average specific absorption rate (SAR) of 0.4W/kg in exposed tissue.

TABLE 1—RELATIVE POWER LEVELS.

WATTS	DEVICE
1,000,000.000	Military radar pulse power
1,000.000	Microwave oven, cooking
200.000	Microwave oven, defrosting
6.000	Portable two-way radio
0.400	18GHz microwave communications
0.100	Radar speedmeter, maximum power
0.012	Radar speedmeter, typical power

Power levels

The risk can be put into perspective by considering the relative power levels for RF equipment and the human body's RF radiation absorption rate.

▶ *Absorption rate*—The body's specific absorption rate (SAR) varies with frequency, so the recommended safe maximum exposure level is determined by a frequency and power density curve. (See Figure 1 to the left.)

Figure 1's vertical axis displays power density in mW/sq cm of exposed

Weimeister is the telecommunications superintendent for the Phoenix Police Department. He has 30 years of experience with microwave equipment as a civilian and as a police officer. He has testified as an expert witness about traffic radar.

tissue. The curve of the standard guideline represents the accepted maximum limit for safe human exposure; the area under this curve defines exposures that are below this limit.

The horizontal axis displays frequency on a non-linear scale.

The SAR chart was calculated based on continuous whole-body exposure for as long as 24 hours a day, 365 days a year. Partial-body exposures and reduced exposure times result in compliance with this standard being very conservative with respect to human safety. More than other standards, this chart is most valuable as a representative measure of exposure that calls attention to the potential hazard.

Most exposure risks are evaluated on a smaller scale.

Laboratory studies have been conducted on animals and cells to identify frequencies and power levels that may pose a threat. These studies are credible, but they require consistent replication to influence changes in standards.

▶ *Power levels*—Just to set the frame of reference, consider the relationship between power levels. (See Table 1 on page 15.)

A shipboard radar may have a pulse power of 1MW. A microwave oven cooks at a power as high as 1,000W and defrosts at 200W.

Microwave communications satel-

Police radar is a valuable commodity

Radar speed measurement equipment has achieved commodity status in law enforcement.

It is the essential tool in speed limit enforcement, regardless of police department size.

Publicity about injuries attributed to RF radiation exposure from traffic radar makes it worth reviewing how traffic radar works.

The radar speedgun transmitter sends a burst or continuous (cw) unmodulated signal. The returned signal is "modulated" with vehicle speed information.

The radar's receiver measures the frequency difference between the transmitted signal and the reflected signal, also called the echo, that returns from the target. This difference is known as the Doppler shift. The Doppler shift indicates how fast the target is moving relative to the radar equipment. Moving radar subtracts the police vehicle speed.

Traffic radar uses radio frequencies with wavelengths so short (10GHz = 3cm) that its radio waves behave much as light waves. They can be focused into a narrow beam with a plane wavefront directed at a moving target.

The moving vehicle modulates the returned signal by raising or lowering the reflected signal's frequency.

For X-band radar, the returned signal shifts 31.4Hz for each mile per hour of speed relative to the radar equipment. For K-band radar, the shift is 72Hz for each mile per hour.

At higher frequencies, radar antennas become smaller. Horn-shaped antennas with higher gain become practical. But signal loss, also called attenuation, increases, and the effective range decreases.

At certain frequencies, the atmosphere absorbs the transmitted radio energy. Atmospheric molecular resonance is the primary attenuation factor in the 23GHz microwave communications band, for example. When rain droplet size approaches a submultiple of the radio signal's wavelength, attenuation increases to the point of total fade.

The radar range equation is:

$$\alpha_s = P_{out} + 2G_{ant} + G_t - P_{in}$$

where

α_s = two-way free-space path loss in decibels

P_{out} = transmitter power output in decibels referenced to a milliwatt

G_{ant} = antenna gain in decibels x 2 for transmit *and* receive function.

G_t = target gain in decibels

P_{in} = receiver sensitivity in decibels referenced to a milliwatt

Target gain is determined by radar cross-section, as shown in Figure 1 on page 15. A tractor-trailer combination has large reflective surfaces approximating the reflective surface of a 10-foot diameter sphere with a 50dB target gain.

For example, the calculation for an X-band radar with a 50mW (+17dBm) transmitter power, a 20dB gain antenna, a 50dB gain target and a −95dBm receiver sensitivity is:

$$\alpha_s$$

$$= P_{out} + 2G_{ant} + G_t - P_{in}$$

$$= +17\text{dBm} + 2(20\text{dB}) + 50\text{dB} - (-95\text{dBm})$$

$$= 202\text{dB}.$$

A free-space path loss of 202dB corresponds with a range of 900 feet, as shown in Figure 2 on page 18.

Receiver sensitivities better than −95dBm are available in modern radar units.

On the other hand, beam dispersion follows the laws of physics, and free-space loss always limits range, even though its amount differs with the frequency.

Free-space loss varies according to the inverse-square law, which means power density reduces rapidly as distance increases from the antenna near-field. This reduction quickly mitigates any potential health hazard as distance from the antenna increases.

lites may use as little as 10W. Terrestrial microwave links operate with about 400mW.

A radar speedgun's output, 40mW, is a tenth of a terrestrial microwave link's power. Although the speedgun's power is small, many medical studies use millionths of a watt to determine cell responses.

High-frequency microwaves only penetrate the skin's outer layers. Lower frequencies go deeper.

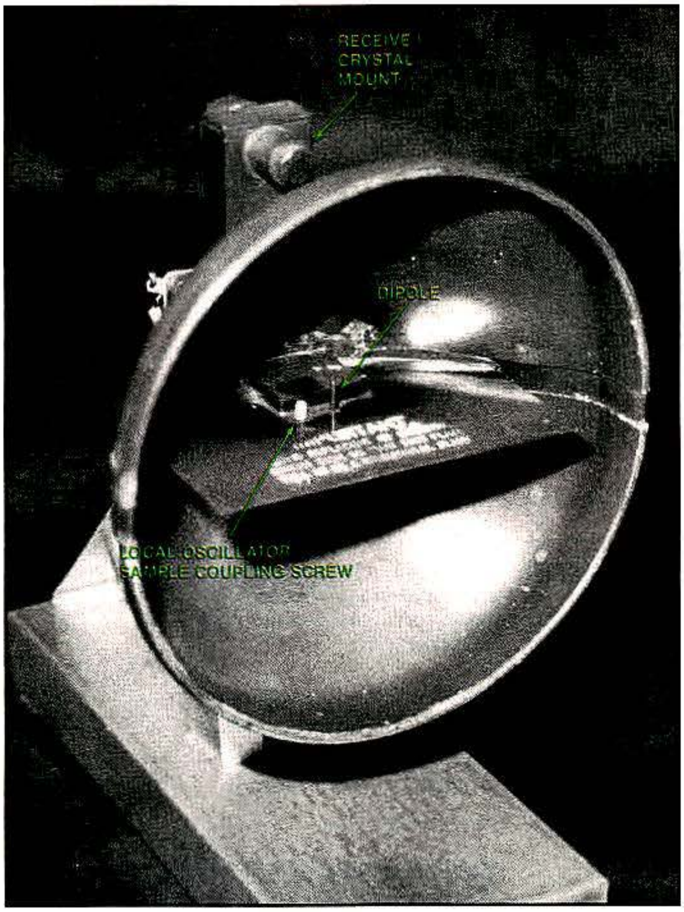


Photo 1. This X-band, 10.525GHz microwave transmitter has a Gunn diode with a 50mW output power. The dish antenna is split into transmitter and receiver halves with a nylon insulated setscrew between them to couple local oscillator energy. The output is focused into a 6° beamwidth to direct it toward a target.

Non-ionizing effects

Researchers evaluate two effects of non-ionizing RF radiation, athermal and thermal.

▶ *Athermal effects*—Athermal effects modify cell growth or the cell nucleus. These effects are the basis for biological studies.

Although circumstantial and emotional claims have been made about the health risk of athermal effects, scientific studies must be the basis for establishing and confirming safe exposures.

▶ *Thermal effects*—With the thermal effect, skin temperature rises as it absorbs radiation, as in microwave cooking.

Based on health studies of both athermal and thermal effects, the Occupational Safety and Health Administration (OSHA) industrial safety standard limits skin exposure to 10mW/sq. cm maximum.

When discussing health effects, keeping a sense of proportion is important. Speedmeter power levels typically are 12mW from the Gunn diode source. Beam forming, by dish or horn, never can raise that power, although it can increase the power density (mW/sq. cm).

RF energy from the speedgun can reach the operator's skin in several ways: from direct exposure to the front of the antenna, leakage to the rear of the speedgun, reflections inside the vehicle and reflections from the target vehicle.

▶ *Direct*—With a typical speedgun, a hand held over the antenna opening would be exposed to 0.31mW/sq. cm, less than $^1/_{30}$ of the maximum specified by OSHA.

Measurements from a large sample of radar units show an exposure of no more than 0.145mW/sq. cm, 2 inches from the antenna face.

Thus, normal operation never approaches the maximum safe-exposure level. In fact, even intentional misuse cannot create a hazardous exposure from either the speedgun's front or rear. An operator using the speedgun in the normal position and inside the vehicle receives an incidental exposure almost 500 times less than the OSHA standard's maximum safe exposure.

Photo 1 above shows an older X-band, 10.525GHz microwave transmitter. Newer radar speedguns operate in the 24GHz K-band, and the newest units use the 35GHz Ka-band. The units' power levels and wave propagation are similar.

The unit in Photo 1 has a Gunn diode with a 50mW output power. The dish antenna is split into transmitter and receiver halves with a nylon insulated setscrew between them to couple local oscillator energy. The output is focused into a 6° beamwidth to direct it toward a target.

Another common police radar, the K-band Falcon, uses a 12° beamwidth with a typical 12mW power output. A gain horn or parabolic reflector focuses the beam, and a turnstile diplexer separates transmit and receive functions.

A narrower, more focused beam provides better lane selectivity and target discrimination. It does not increase output power, though it raises the milliwatts-per-square-centimeter power density and delivers more power in the target's direction.

Some people misinterpret antenna gain as increasing the power level. It does not. Power cannot exceed what the source generates.

The gain horn's taper, rectangular or circular, serves to match the Gunn cavity's impedance to free-space impedance—the taper acts as an RF transformer. Polystyrene rods can transform the impedance, too, once again without power gain.

▶ *Leakage*—The transmitter uses such low power that the RF source and the antenna must be well-sealed to prevent leakage loss that would render the unit ineffective. Laboratory studies indicate that no measurable RF energy can be detected on a radar speedgun's operator side.

▶ *Interior reflections*—Specular reflection within a vehicle further dis-

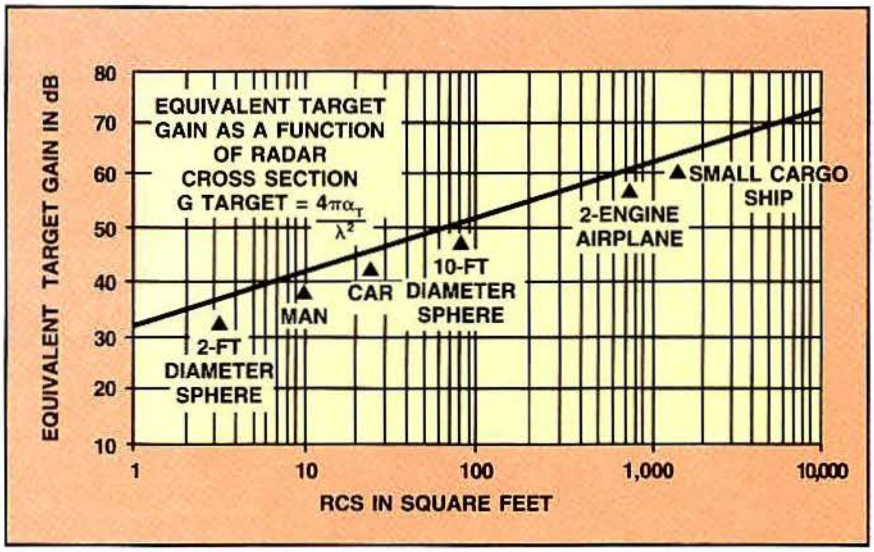


Figure 2. The metallic target area the radar beam intercepts determines the returned signal's power level and phase. The target area, called radar cross-section (RCS), corresponds to equivalent target gain. Smooth or contoured surfaces are poor targets, and right-angle corners are excellent targets (corner reflectors).

perses the microwave beam, mitigating risk.

▶ *Exterior reflections*—The amount of RF radiation that returns to the speedgun operator after reflecting from a target vehicle can be calculated.

How much energy returns depends on the radar transmitter power, the antenna gain, the target vehicle size and shape and atmospheric conditions.

Each doubling of transmitter power provides a 3dB increase. Any vehicle body shapes that form a trihedral corner reflector provide excellent target antenna gains. Surfaces that reflect the signal upward or downward or absorb the RF are operating in stealth mode. They provide poor radar reflections.

Here are the assumptions for the calculation:

(1) *The transmitter power is 50mW.*

The 50mW equals +17dBm; the calculation is easier in decibels.

Although most modern speedguns use lower power, the following example uses a 50mW power output representative of older speedguns that might remain in use. Lower power reduces any potential health hazard.

(2) *The antenna gain is 20dB.*

(3) *The target gain is 50dB.*

The metallic target area the radar beam intercepts determines the returned signal's power level and phase. The target area, called radar cross-

section (RCS), corresponds with an equivalent target gain as shown in Figure 2 on page 18.

For this example, the target is assumed to be a 10-foot diameter sphere that provides a target gain of 50dB. The RCS of a large automobile is 12 sq. ft., with an equivalent target gain of 45dB.

(4) *The signal is traveling through free space.*

The amount of energy that returns is equal to the transmitter power + antenna gain + target gain − two-way free-space path loss.

Figure 3 to the right shows the two-way free-space path loss for distances from 10 feet to 10,000 feet.

A traffic radar activated 10 feet from a vehicle would have 120dB of two-way free-space path loss.

The RF energy reflecting from a vehicle 10 feet away would be:

$$+17\text{dBm} + 2(20\text{dB}) + 50\text{dB} - 120\text{dB}$$

$$= -13\text{dBm}$$

$$= .05\text{mW}$$

which is $^1/_{500}$th of the power of the radar speedgun, so little power that it represents no hazard.

The farther the target vehicle is from the speedgun, the weaker the reflected signal that returns to the operator.

▶ *Motorist exposure*—The motorist is exposed to the direct wave. As was explained before, even placing a hand over the speedgun antenna does not expose the skin to more than $^1/_{30}$ of the OSHA safe exposure level. Thus, a motorist tens or hundreds of feet away is exposed to energy levels many orders of magnitude below the maximum safe level of 10mW/sq. cm.

Properly used, with the speedgun pointed away from the body or at the ground when idle, radar poses no threat to the officer or motorist.

Antenna sealing and directivity ensure that transmitted energy is directed toward the target without harmful leakage.

Free-space loss calculations show that the miniscule amount of energy that returns from the target is barely detectable.

Using radar as it is intended for speed surveys and law enforcement does not expose anyone to RF radiation levels that even approach the maximum safe exposure limit.

Further analysis of objective studies is required to establish any correlation between claimed injuries and RF radiation exposure.

The RF radiation from current traffic radar equipment falls well within the OSHA standard, so there is no gross risk to health posed by its use. Common-sense use of the radar speed measurement equipment is the best advice.

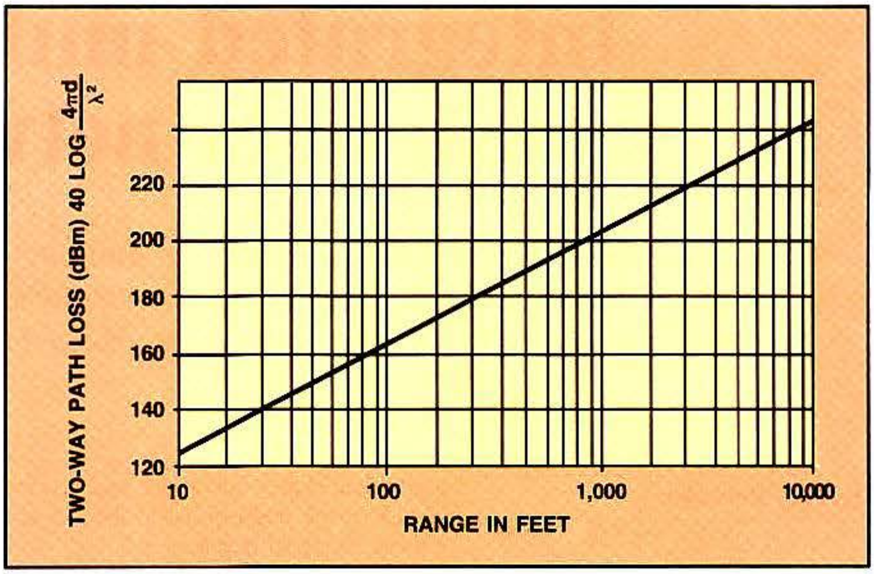


Figure 3. The two-way free-space path loss for distances from 10 feet to 10,000 feet. For example, a traffic radar activated 10 feet from a vehicle would have approximately 120dB of two-way free-space path loss.

Integrated multisite voice, data networks

Trunked radio data products provide the building blocks for an equitable balance between today's choices and tomorrow's requirements as radio communications traffic content shifts from primarily voice to primarily data.

By Tom Robinson

The city government today unveiled to the public its new radio system that is helping in the fight against budget bloat as well as crime in our city. The system features the latest in integrated trunked voice and data technology to improve productivity, to make officers on the street more effective and to streamline operations throughout city government. This multi-million dollar investment is paying off for the citizens of Any Town.

—*TV News, Any Town, U.S.A. 1993*

Is this a communication director's wish? Or is it reality?

The benefits of mobile data communications have been publicized for some time; nevertheless, mobile data has not been widely adopted. As mobile data comes into wider use, reports such as the one printed to the left are more likely to happen.

Robinson is program manager for private mobile data at Ericsson GE Mobile Communications, Lynchburg, VA.

New technology and a new approach combine to make it easy to extend a trunked voice radio communications system and an existing information infrastructure with mobile data. Mobile computing now can be an extension of office-based applications rather than a do-it-from-scratch, custom development effort requiring man-years of agonizing effort and new, complex interfaces.

The mobile computing capability is extremely important as organizations shift from the "go-go" attitude of the '80s to the "do more with less" requirements of the '90s. The challenge for today's network providers is to answer tough questions from decision-makers, such as:

▶ How will mobile data improve productivity?

▶ How will mobile data integrate with my existing management information system (MIS)?

▶ How will it help to re-engineer work processes to upgrade customer service despite a shrinking work force?

The technology was conceived and executed with these real and legitimate concerns in mind. It gives communications system managers the ability to provide solutions which result in the necessary productivity improvements.

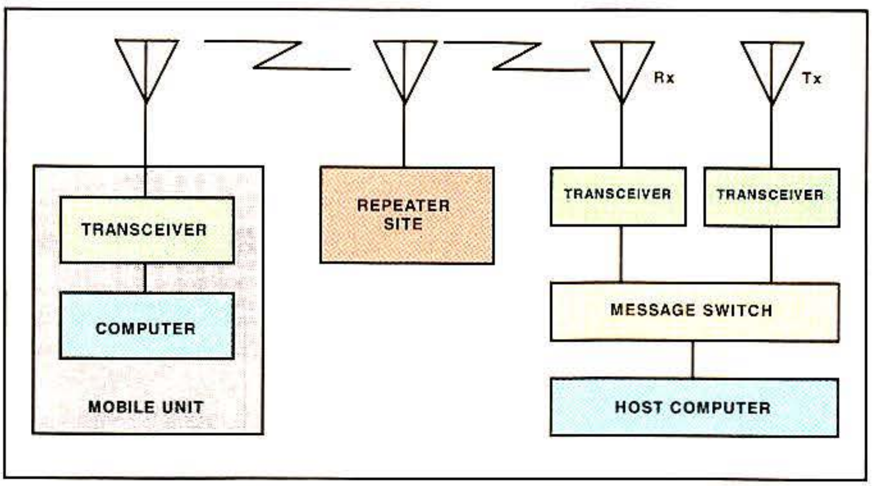


Figure 1. RF-to-RF systems communicate over the air. This configuration is the easiest and most cost-effective to implement.

Trunked radio

Modern trunked radio systems' advantages are well-known and appreciated.

In use since the mid-1980s, these systems have proved capable of delivering more equivalent call-handling capacity than conventional systems. The advantages to users include:

▶ increased day-to-day operating efficiency.

▶ improved coordination and radio-to-radio communications between agencies.

▶ improved safety for police and other critical employees.

▶ intrinsic privacy.

Integrated network planning

Wireline networks increasingly handle all types of traffic, including voice, digital computer information and imaging.

A wire-based local-area network (LAN) designer balances cost versus future traffic and user capacity when selecting the media.

For example, a simple peer-to-peer network uses a twisted pair or thinnet, narrowband coax. A more complicated

network requires thicknet, wideband coax or fiber optics.

An RF network designer faces the same trade-offs, with the addition of one more variable, radio. Voice communication has been, and for the short term, will continue to be, the primary reason for installing a dispatch radio system.

Mobile data traffic will increase over time, replacing routine voice checks with automatic database look-ups and digital dispatch.

A modern integrated RF network inherently transmits clear voice, digitized voice and digital data on all channels. Such a network adapts to call types as required.

It handles today's voice traffic and will adapt dynamically to tomorrow's increased mobile data traffic. It might well be called an *infinitely variable transport network*.

A single integrated network offers lower initial investment and maintenance expense while providing intrinsic and facile expansion. Together, these advantages increase the likelihood that mobile data can and will be widely implemented in the near future.

Voice communication has been, and for the short term, will continue to be, the primary reason for installing a dispatch radio system.

For example, one such integrated trunked radio system with a fast-access, fully integrated digital trunked radio platform supports the transfer of data among pieces of standard computer hardware via RF. Its hardware interface, protocols and methods comply with the open systems interconnect (OSI) model for communications systems.

Mobile data

Two distinct configurations exist for mobile data.

A data gateway provides a computer industry standard bridge between the trunked radio network and the customer's existing information infrastructure. A single interface to the radio system is made at the console electronics controller (CEC) or integrated multisite and console controller (IMC).

The modular architecture provides a seamless upgrade from voice networks to single or multisite voice and data networks. The same high-speed communications links established for voice communication carry data calls.

Host applications need not be modified to accommodate RF-to-RF systems. In addition to standard RS232/ASYNC protocol, the data gateway supports TCP/IP and X.25 host network connections. Port capacity may be from one to eight, depending on host protocol and traffic requirements.

The data gateway fully supports both individual and

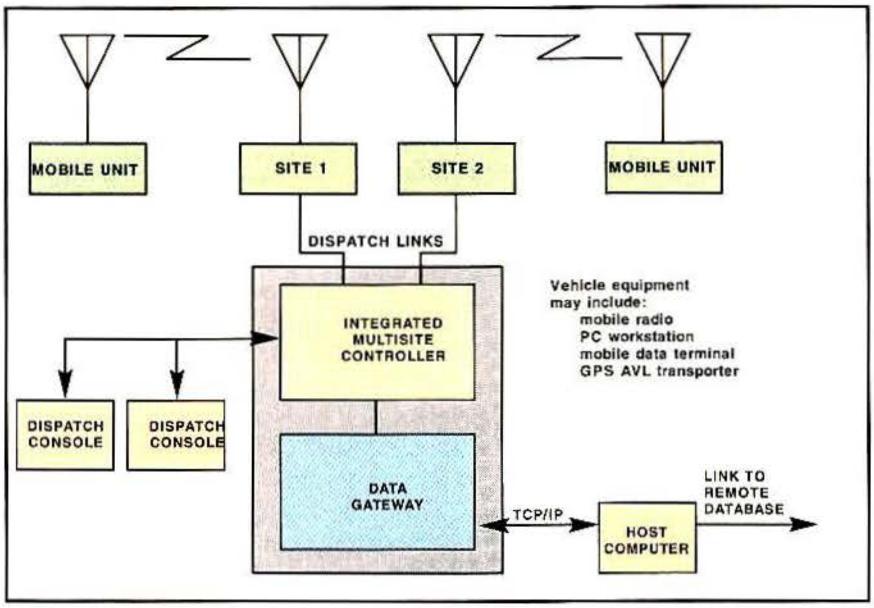


Figure 2. In networks with more than one RF site, a landline mobile data configuration is used. Whether configured as shown in Figure 1 or Figure 2, the RF network must be linked to the existing computer network.

host originated group data calls across either single or multiple sites. Data messages can be transmitted to individual radios or broadcast to a talk group simultaneously, even over multiple sites.

The product builds on the trunked radio system's capacity to manage traffic with predetermined priorities by allowing the system administrator to define a queue depth. A first-in, first-out convention routes queued calls to the host from the mobile.

The TCP/IP and X.25 gateway products support host-to-radio priority call queuing and peer-to-peer messaging.

All I/O ports support a rotary function on both the host and radio system. This support data calls to be processed over the first available port.

The rotary feature, combined with a configurable number of interface ports, optimizes data gateway call throughput.

Software interface

Mobile data communications originally used proprietary operating system software, hindering widespread adoption.

Use of a standard, open operating system, MicroSoft disk operating system (MS-DOS), accelerated the personal computer (PC) revolution. A parallel opportunity exists in mobile data.

A software application programmers interface (API) enables any MS-DOS based personal computer to function as a mobile data terminal on the trunked radio system. The software interface simplifies the development of customer specific applications on standard hardware platforms by providing a standardized "toolbox" of communications routines.

These routines then link directly into an application. The software interface provides the communications routines that will help programmers to create the *mobile office*.

Customers or third-party application software suppliers use the software interface and existing PC experience to develop new applications or to modify existing ones. The software interface is not frequency dependent, so it works with all existing and future compatible trunked radio systems.

The software interface implements IBM's command-level interface for mobile data applications. The complementary nature of this interface allows application programs developed by IBM and its partners to *plug and play* on the trunked radio system. This reflects a cooperative strategy between IBM and the system manufacturer.

Conclusion

The paradigm has shifted.

Learning from the PC revolution of the 1980s, mobile data communications equipment suppliers are evolving their systems into open systems. Such open systems provide standard interfaces at each end of the RF transmission to allow easy connection of the RF *pipe* to virtually any similarly open device.

Network planners now have the tools to answer the challenges of the '90s:

How will mobile data improve productivity? By providing the mobile worker access to existing information resources.

How will it integrate with an existing MIS system? By combining computer industry standard network protocols and intelligent mobile workstations to mirror the office environment.

How will it help to re-engineer work processes to upgrade customer service despite a shrinking work force? By empowering the worker with direct access to information, allowing available resources to be applied directly to improving customer service.

The integrated network maximizes available hardware and software choices.

Mobile data terminal options range from traditional purpose-built mobile data terminals (MDTs) to standard MS-DOS pen-top, notebook or laptop PCs. Standard RS-232/ASYNC, TCP/IP, X.25 packet-switching or IBM SNA interfaces link existing host computers and networks to trunked radio communications systems.

The existing network applications employ advanced *middleware* or APIs that effectively extend the host and desk-bound applications to the field via the RF media.

Trunked radio data products provide the building blocks necessary to achieve an equitable balance between today's choices and tomorrow's requirements. Traffic profiles are shifting from primarily voice to data. Operational and capital budgets and organizational resources are under pressure. The decision made today influences the ability to accommodate tomorrow's requirement.

Radiating cable radio system speeds emergency response

Designing and constructing a radio system with radiating coaxial cable may be easier than you think. Here is an example of a system that allows a UHF frequency to be reused within 30 miles in the Los Angeles basin.

By Jay Devadoss

Security guards and building maintenance workers can respond to emergencies faster since the Los Angeles County Department of Public Works installed an on-site two-way radio and radiopaging system.

Radiating coaxial cable limits the radio coverage to a local area that includes the department's main office building, cafeteria, annex and parking structure. The system serves 25 portable radios and 30 pagers.

Frequency coordination

The system uses a UHF repeater frequency pair licensed to the department by the FCC for underground use.

Permission from the nearby city of Yorba Linda, CA, was required because the city uses the same frequencies for above-ground radio communications. The department has to confine its radio system coverage to a radius of one mile from the headquarters building.

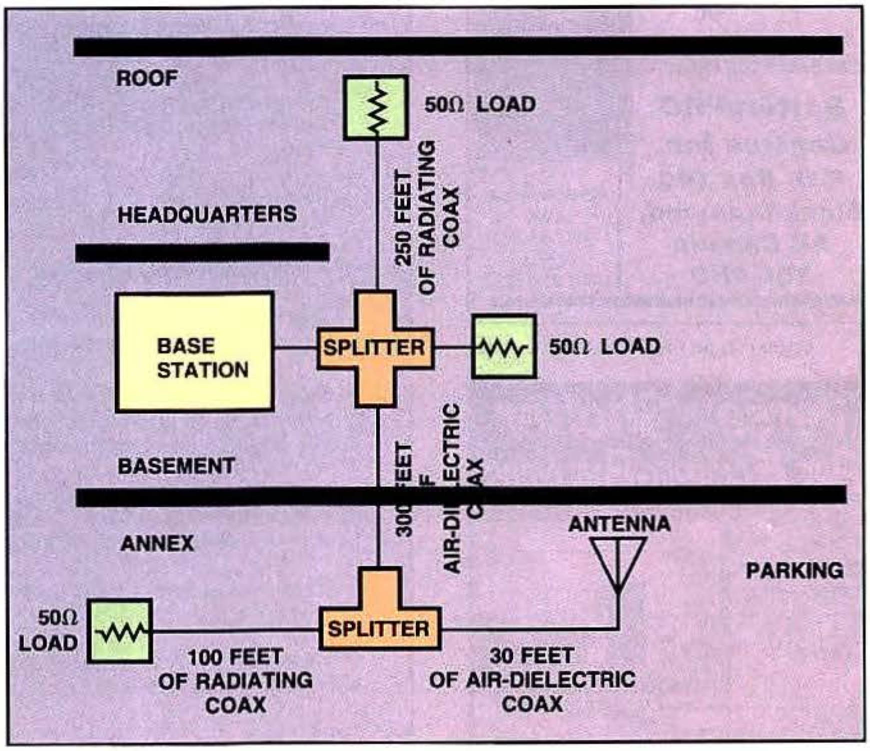


Figure 1. The department's two-way radio and radiopaging system uses radiating coaxial cable and a 6dB gain antenna to serve its main building, annex and parking structure. The system includes a 30W base station and two power splitters.

System configuration

The main building measures 225 feet from basement to rooftop. The annex is a 3-level building, and the parking structure has two levels. Both buildings are about 150 feet from the main building.

The base station is located in the main building's basement, and its output feeds a 3-way power splitter. (See Figure 1 above.)

Two splitter ports feed cable runs to the main and annex buildings. The third port is terminated with a 50Ω load for future use.

The radiating cable serving the main building measures 250 feet. It was routed through an existing telephone and computer cable duct at the center of the building.

The radiating cable inside the annex measures 100 feet.

Routed through an existing underground conduit, 7/8-inch diameter air-dielectric cable connects the headquarters building base station to the radiating cable in the annex.

No underground conduits serve the parking structure, and cables may not be routed overhead. Thus, the parking structure is served by a 6dB gain antenna in an equipment room in the annex building, facing the parking structure.

Devadoss is principal assistant engineer for the Los Angeles County Department of Public Works, Los Angeles. He has earned B.S.E.E. and M.S.E.E. degrees from California State University, Los Angeles.

Calculations

The system calculations are based on communication from the portable unit to the base station[1] because the portable unit's transmit power is considerably lower than the base station's.

SYSTEM ELEMENT	POWER BUDGET
Portable transmit power, 2W	33.0dBm
Base station sensitivity, 0.5μV	–113.0dBm
Radiating cable attenuation at 450MHz (2.244dB/100ft. for Andrew RXL 4-1, 350 feet)	–7.9dB
Power splitter losses	–8.0dB
Coupling loss for 80 feet, 74dB at 20 feet	–86.0dB
Air-dielectric coaxial cable, Andrew Heliax, 0.896dB/100ft., 330ft.	–3.0dB
System loss factor	–15.0dB
Received power = total loss – transmit power	–87.0dB
System gain = received power – receiver sensitivity	26.0dB

Coupling loss is defined as the difference between the signal level in the radiating cable and the signal received by a 0dBd gain antenna, and it is specified in decibels for a distance of 20 feet[2].

Each side of the main building is about 80 feet from the radiating cable. Hence, this value was chosen to calculate coupling loss. Every time the distance from the cable is doubled, 6dB of loss is added to the calculations.

System loss factor is used to account for environmental conditions, such as type of building. A value of 15dB loss is advised by the cable manufacturer.

System reliability is measured as system gain. The cable manufacturer recommends a minimum value of 15dB.

References:

1. Andrew catalog 35.
2. Andrew bulletin No. 1058F.

The antenna is connected at the end of a 30-foot length of air-dielectric cable extending from a 2-way power splitter at the annex. The rest of the annex is served by a 100-foot length of radiating cable routed in the other direction from the splitter.

Equipment

The system uses a Micor base station, Saber portables and Bravo pagers by Motorola. The base station power output is 30W.

The Zetron paging encoder can page as many as 100 units.

Designing a system

Designing an in-building radio communications system using radiating cable is not arduous. With proper planning and simple calculations, a highly reliable radio communications system can be designed.

Example calculations for the department's system are shown above.

9-1-1 service expands toward universal coverage

Technology is the name of the game, according to Sheriff Matt Lori of St. Joseph County, MI. The rural county upgraded its emergency communications with 9-1-1 telephone service and central dispatching.

By Don Bishop
Editorial Director

In most of the country, people dial 9-1-1 on a telephone for emergency help, and within minutes, the right kind of help arrives in the form of police officers, firefighters or medical service.

In other parts of the country, 9-1-1 systems still are being built. Eventually, universal 9-1-1 emergency service will be available.

Many local government officials learn from the experiences of colleagues in other jurisdictions and take advantage of advice from consultants to smooth the transition to 9-1-1.

For example, Art McDole, a former director of communications for Monterey County, CA, said that previous difficulties involving proper telephone call routing and disagreements among public safety agencies as to who should answer the phone largely have been resolved.

No. 1 problem

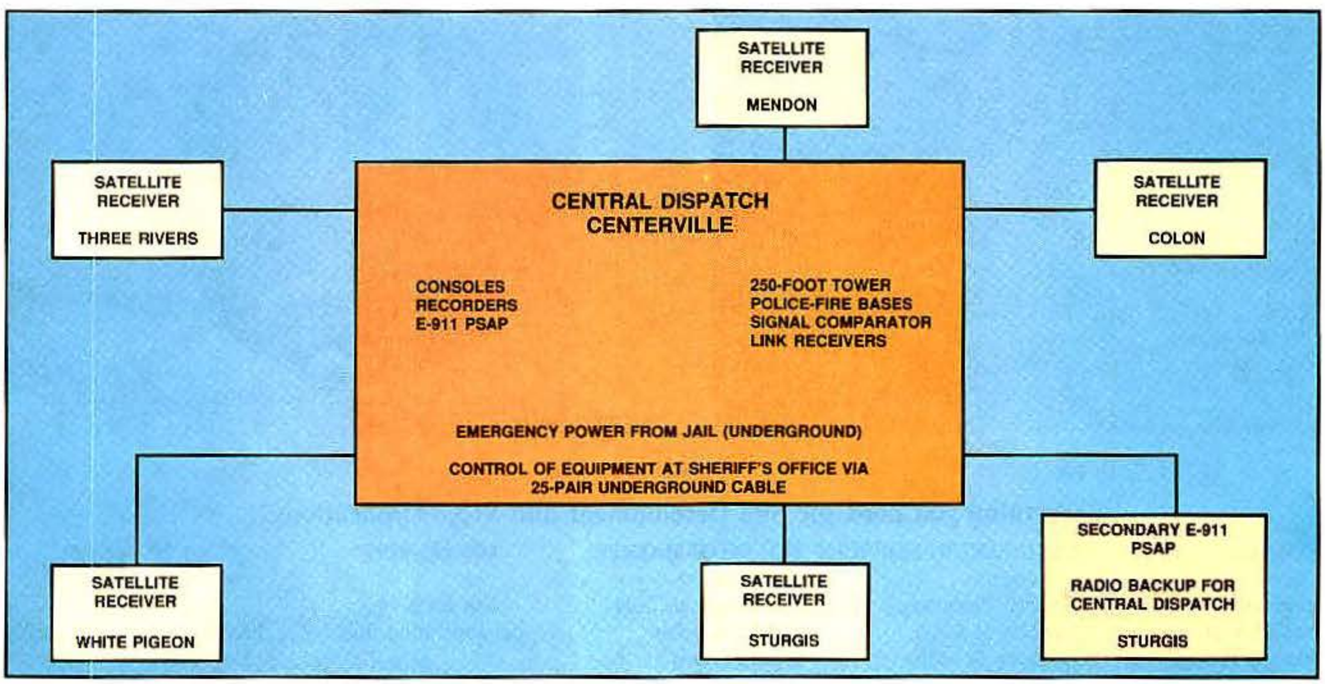
"Money," he said, "remains the number one problem.

"Funding sometimes comes in a haphazard fashion," he explained. "Sometimes local government has to pay the cost, sometimes there is a surcharge on telephone calls, and sometimes a referendum is placed before the voters," he said.

California pays for all of the 9-1-1 systems in the state via a tax on monthly telephone service bills, not including long-distance charges.

In St. Joseph County, MI, where a 9-1-1 system was installed this year, voters approved a property tax to pay for 9-1-1 service. The Michigan state government is requiring all local governments to provide the service by 1996, but without state funds.

According to the county sheriff, Matt Lori, voters approved a plan that con-



The basic diagram for St. Joseph County, MI's central dispatch system.

solidates emergency telephone answering and radio dispatching for St. Joseph County. "Naturally, we had a tremendous amount of problems because the central dispatching and the technology involved is new for us," the sheriff said.

"It is hard to mesh the desires of several fire departments, several emergency services responders and several police departments that have done things their own way for 30, 40 and 50 years and put dispatching into one unit that does all the little things that will please everybody. Everyone has done a good job of compromising and agreeing on the important issues," he said.

Along with the 9-1-1 system, the county installed a new 3-channel 450MHz radio system that Lori said provides nearly 95% coverage with portables throughout the county.

The sheriff said that he never would have guessed that there would be so many things to decide in connection with the 9-1-1 project; therefore, when asked what advice he would give to others, he said to try to get as many technical people on board as possible.

"There are a lot of decisions to make about computers, software, uninterruptible power supplies, radios and telephone lines," he said. "Technology is the name of the game. Just figuring it out and understanding it is a major problem.

"We went from no computers to all computers for everyone in the county," Lori continued. "Everyone who works here is from the area, which is a rural community, and at first they didn't want to touch the computers. Now, when the computers go down, people moan and groan about how they can't do anything without them."

Committee guidance

To guide the project, a nine-member committee headed by the sheriff was formed according to state guidelines.

Committee members represented law enforcement, fire and emergency services, the county commission, villages and cities, the state police and the general public.

R. James Evans of Evans & Evans Associates, East Lansing, MI, one of the consultants who helped with the project, said the 9-1-1 system had to be designed to operate on a maximum $500,000 annual budget based on the tax. Some county agencies saved money from their budgets, though, because the project consolidated some of their telephone and radio communications services.

Evans said the project went smoothly because of the committee. "Another county we worked with never had a committee," he said, "and its 9-1-1 project went topsy-turvy because the county never had someone with a finger on the pulse. St. Joseph County's committee was very important to the success of the project."

The committee had to decide whether additional dispatchers would be needed to take care of the extra work. Evans estimated the number of calls and the number of dispatchers they would need to answer the calls.

"With only the tax money to keep the entire system going, the 9-1-1 communications center was limited as to the number of people it could hire," Evans said. "The county has no extra funds to assign to it."

Address guide

The project benefited from volunteer work performed by some of the committee members. For example, Terry Krull, an at-large committee member from Constantine, MI, compiled information for the *mobile street address guide* (MSAG), the stored information that the computer refers to when an emergency telephone call is received.

"The county equalization department supplied me with a numerical order listing of street addresses," she said, "and the county road commission helped with rural addresses. Duplicate names and addresses had to be resolved on an individual basis with a lot of letter-writing and telephone calling to the specific individuals requesting correct information."

Krull said that the telephone company supplied information, too, but unfortunately, it had a lot of errors.

"We needed the MSAG for our computer-aided dispatch," Krull said.

The reason for getting each address correct is because when a person dials 9-1-1, the information that comes on screen in the communications center displays the person's name, address, telephone number and special information such as the presence of handicapped or bedridden individuals or hazardous materials. Even if the caller cannot speak, information from the MSAG that appears on screen automatically allows the dispatcher to notify the police properly.

"The screen also lists the responding police, fire and rescue unit for the county," Krull continued. "If no one speaks to the dispatcher, the dispatcher calls the number back. If there still is no response, the procedure is to send the police, and the police determine whether other help is needed. Sometimes children dial 9-1-1 and hang up. Dispatchers respond to all calls, by returning the call or sending police."

Consultants

Krull said consultants were hired because the county did not have all of the required expertise. Along with Evans, John Dorsey of Dorsey & Associates, a Detroit-area consulting company, was hired for computer advice.

"We paid a lot of money, but I think it was worth it," Krull said. "I would advise anyone to get a consultant, someone who has been through it before. Sometimes advice is available from a neighboring city or county that has completed a 9-1-1 project. We went with private consultants on the recommendation from a neighboring county."

Krull continued: "As with any program, you always think you have the correct information from vendors, but make sure you ask every question you can think of and get clear, straightfor-

ward answers."

Speaking of vendors, Evans said that GTE was selected as the 9-1-1 equipment vendor in part because the company provides exchange telephone service in the county. "It was logical to go with their computer access systems," he said.

"There were a few problems making the telephone line connections into some of the 9-1-1 reception equipment supplied by another vendor for the dispatch console area, but it all shaped up eventually," Evans said.

E-9-1-1

The number 9-1-1 serves as a telephone number for summoning emergency help in many parts of the country.

Electronic systems for handling calls to the emergency telephone number are known as 9-1-1 and E-9-1-1 systems. In E-9-1-1, *E* stands for *enhanced*. The difference is that E-9-1-1 systems automatically display previously stored information about people and places at the other end of the telephone line, such as telephone numbers, names, addresses, medical histories and location descriptions.

Automatic number identification (ANI) displays the number of the telephone originating the call, and *automatic location identification* (ALI) displays the address where the telephone is located.

Calls dialed to 9-1-1 are routed to a *public safety answering point* (PSAP). At some PSAPs, dispatchers obtain information from the caller and dispatch police, fire and emergency medical services.

In some systems, PSAP operators route calls to dispatchers at secondary PSAPs at appropriate public safety agencies that can help the caller. In the more sophisticated systems of this type, ANI and ALI information is routed along with the call.

St. Joseph County installed an E-9-1-1 system.

Future technology

Art McDole said that, in some areas, the use of cellular telephones to dial 9-1-1 causes confusion.

For example, in California, cellular calls to 9-1-1 are routed to highway patrol offices because in the early days of cellular use, most calls came from moving vehicles and reported traffic accidents.

"Today, cellphones go anywhere, and the highway patrol receives a lot of calls that are not traffic-related," he said. "This requires a backward process of passing calls to the proper agencies. For the most part, the highway patrol has no way to transfer calls directly, so the information has to be taken down and relayed."

A future technology that may affect 9-1-1 systems is personal communications service (PCS). "If PCS goes through as we read about, and when everyone carries a pocket phone, what will we do about ANI and ALI?" McDole asked. "ALI is especially critical, because in many instances, lives have been saved because we can respond to an address if a caller such as a small child or a person under duress cannot speak, or if the call is dialed by automatic equipment."

As does cellular, PCS relays telephone calls through radio base stations. McDole said that the Associated Public-Safety Communications Officers, a trade association in South Daytona Beach, FL, has asked the federal government to consider requiring PCS systems to send some kind of identification code that would give 9-1-1 systems the PCS cell location to reduce the area that might have to be searched to find the caller.

McDole said that ANI dramatically reduces the number of prank calls from pay phones and everywhere else. "It cuts the wasted responses and the waste of dispatchers' time. In early days, prank calls posed quite a problem," he said.

Regardless of the difficulties connected with installing a 9-1-1 system, McDole said, "the payoffs are worth the problems and costs a thousand times over. It has been a godsend."

Classified

Advertising rates in **Mobile Radio Technology's** Classified Section are $69.00 per column inch, per insertion, with frequency discounts available. There is a one inch minimum.

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Tower space

Equipment wanted

Equipment for sale

Circle (26) on Fast Fact Card

Computer software

Circle (27) on Fast Fact Card

Use Mobile Radio Technology Classified Ads

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DX Radio Systems	9	5	213-257-0800
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